♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

1413 Precision

Decade Capacitor

User and Service Manual

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1413 im/May, 2003

IET LABS, INC.
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WARRANTY

We warrant that this product is free from defects in material and workmanship and, when properly used, will perform in accordance with applicable IET specifications. If within one year after original shipment, it is found not to meet this standard, it will be repaired or, at the option of IET, replaced at no charge when returned to IET. Changes in this product not approved by IET or application of voltages or currents greater than those allowed by the specifications shall void this warranty. IET shall not be liable for any indirect, special, or consequential damages, even if notice has been given to the possibility of such damages.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTIBILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

WARNING

OBSERVE ALL SAFETY RULES
WHEN WORKING WITH HIGH VOLTAGES OR LINE VOLTAGES.

Dangerous voltages may be present inside this instrument. Do not open the case
Refer servicing to qulified personnel

HIGH VOLTAGES MAY BE PRESENT AT THE TERMINALS OF THIS INSTRUMENT

WHENEVER HAZARDOUS VOLTAGES (> 45 V) ARE USED, TAKE ALL MEASURES TO AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS.

USE MAXIMUM INSULATION AND MINIMIZE THE USE OF BARE CONDUCTORS WHEN USING THIS INSTRUMENT.

Use extreme caution when working with bare conductors or bus bars.

WHEN WORKING WITH HIGH VOLTAGES, POST WARNING SIGNS AND KEEP UNREQUIRED PERSONNEL SAFELY AWAY.

CAUTION

DO NOT APPLY ANY VOLTAGES OR CURRENTS TO THE TERMINALS OF THIS INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS INDICATED ON THE FRONT PANEL OR THE OPERATING GUIDE LABEL.

Section 1
Introduction

1.1 Purpose

The Type 1413 Precision Decade Capacitor is both a high-quality, wide-range standard and a reliable component for systems. It can be used as a bench model for versatility, or it can be rack-mounted.

This six-decade capacitor features fine adjustment over a wide range of capacitance, with excellent accuracy. Any value in the range of 0 to 1.111 11 μF can be set, with a resolution of 1 pF.

Other units up to 10,000 μF are available; consult IET.

1.2 Description

The six decades have steps of 1, 10, 100, 1000 pF, and 0.01 and 0.1 □F. Air capacitors are used for the two lower decades, with precision silvered-mica capacitors for the others. Air trimmers are used for trimming the two lowest silvered-mica decades.

The connections to the inner shield and to the case are shown in Figure 1-1. Low terminal-to-guard and detector-input capacitances are obtained by dividing the shielding into two parts. When the two parts are connected together, the 1413 becomes a well-shielded three-terminal capacitor with extremely low zero capacitance. The connections are made by means of BNC connectors on the rear of the cabinet. The inner contacts provide the connections to the capacitors. The outer shells connect to the shields and, when connected together, form the third terminal of the capacitor.

The stability of the 1413 (refer to Specifications) is such that it should not require readjustment with normal service. However, should it become desirable, the four lower decades contain trimmer capacitors that are accessible for this purpose (refer to Section 5.4).

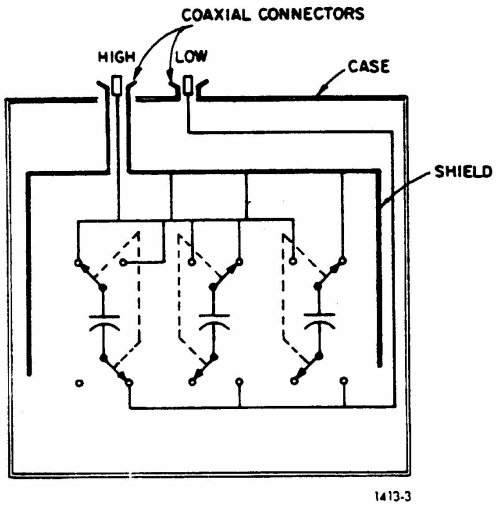


Figure 1-1. Elementary schematic diagram of the Type 1413 Decade Capacitor. Connections for all 24 capacitors are similar to those for the three capacitors shown.

1.3 Controls and Connectors

The controls and connectors on the front and rear of the 1413 are shown in Figures 1-2 and 1-3.

1.4 Inspection and Unpacking

Inspection - If the shipping carton appears damaged, contact the carrier immediately and request that their agent be present when the instrument is unpacked. If the instrument appears to be damaged when unpacked, have the agent witness its condition, take photos of the instrument and carton, and retain the carton until the matter is resolved. Perform an electrical check immediately to determine if any internal damage has occurred and file any required claims with the carrier. It may be necessary to return the instrument to IET
for evaluation, repair estimate and actual repair.

Unpacking - The instrument is wrapped in plastic, and desiccant may be included if the environmental conditions and destination warrant. Do not unwrap the instrument until ready to use or install. For bench use, the bail will raise the front of the instrument if desired. Refer to 2.2 for rack-mounting instructions.

Figure 1-2. Front panel on the Capacitor. Six 11-position switches with knobs and dials to set desired value of capacitance between HIGH and LOW terminals.

Access holes for trimmer Capacitors.
HIGH BNC connector. (874 optional)
LOW BNC connector. (874 optional)
Cover Plates to protect setting of trimmer Capacitors.

Figure 1-3. Connection on the rear panel of the 1413.

Section 2
Specifications

Range: 0 to 1.111 11 □F. controlled by six in-line-readout dials.

Accuracy: ±(0.05% + 0.5 pF) at 1 kHz.

Stability: ±(0.01% +0.1 pF) per year.
Temperature coefficient:
<<20 ppm/°C from 10 to 50°C.

Zero Capacitance: <0.1 pF.

Voltage Rating: 500 V pk max up to 10 kHz.

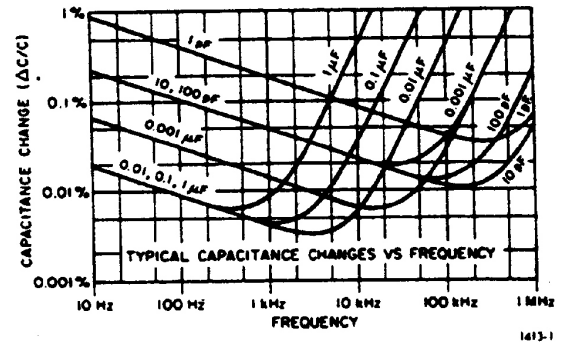
	1 pF to 100 pF	101 pF to 1000 pF	1001 pF to 2000 pF	2001 pF to 0.1 μF	0.1 μF to 1.11111 μF
Dissipation Factor, max at 1 kHz	0.002	0.001	0.0005	0.0003	0.0004
Insulation Resistance, 3 term., after 2 m at 500 V dc	≧ 5 x 10^{10} Ω				≧ 5 x 10^{9} Ω
Terminal Capacitance, max					
high to case	4 pF	8 pF	10 pF	30 pF	60 pF
high to guard	80 pF	105 pF	115 pF	165 pF	200 pF
low to guard	45 pF	70 pF	80 pF	110 pF	120 pF

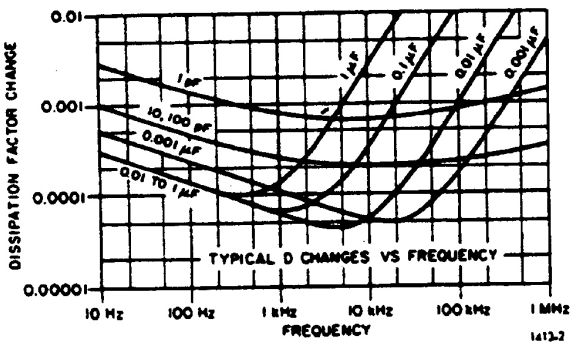
Interface: Connections, 2 rear-mounted bnc connectors, adaptable to most other types.

Available: 0480-9703 Rack Adaptor Set to convert bench models to rack models.

Mechanical: Convertible bench/rack cabinet.
Dimensions (w x h x d):
17 x 5.59 x 11.96 in. (432 x 142 x 304 mm);
rack 19 x 5.22 x 10.9 in. (483 x 133 x 505 mm).

Weight: Bench 23 lb (10.5 kg) net, 29 lb (13.5 kg) shipping; rack 24 lb (11 kg) net, 30 lb (14 kg) ship-





Catalog Number	Description
1413-9700	Bench Model
1413-9701	Rack Model
0480-9703	Rack-Adaptor Set

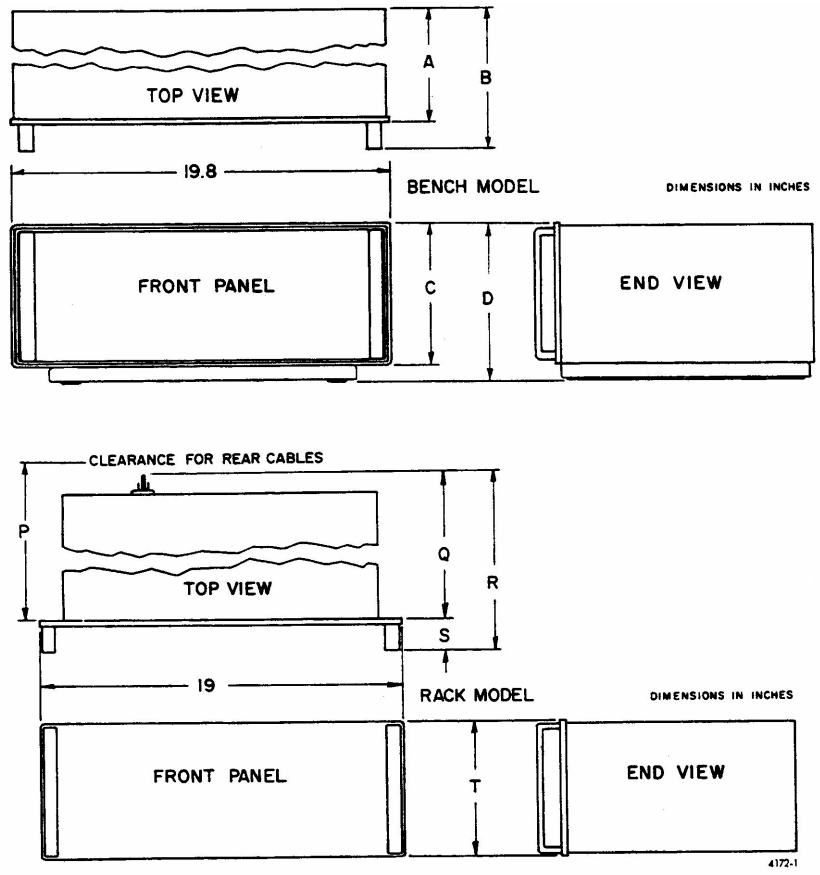
Section 3
Operating Procedure

3.1 Dimensions

The dimensions of both the bench and relay-rack models of the 1413 are shown in Figure 3-1, and are also listed in Section 2.

3.2 Mounting

The 1413 may be ordered enclosed in a cabinet for bench use (P/N 1413-9700). If ordered for rack mounting (P/N 1413-9701), it is shipped with Rack-Adaptor Set P/N 0480-9703, which includes all hardware necessary for mounting the instrument in a standard 19-in. rack or cabinet (refer to Table 3-1). (Order the Rack-Adaptor set alone if a bench model is to be converted for rack mounting.)



Bench Model
A = 10-25/32
B = 11-31/32
C = 5-7/32
D = 5-19/32

Rack Model
Q = 10-21/32
R = 12-5/32
S = 1-1/2
T = 5-7/32

Figure 3-1. Dimensions of the bench and relay-rack models.

Table 3-1
PARTS INCLUDED IN RACK-ADAPTOR SET
P/N 0480-9703

Fig. 3-2 Ref	No. Used	Description	Part No.
C	2	Rack-Adaptor Assembly (handle)	0480-4903
	1	Hardware Set	0480-3080
		Includes:	
D		4 Screws, BH 10-32x 5/16"	
E		4 Screws, BH 10-32x9/16", with nylon cup washers	

CAUTION

Remove the cabinet only when converting the instrument from bench to rack mounting or vice versa. Use extreme care. Do not change the position of the leads or components, as doing so may alter the calibration. IET recommends taking accurate spot readings before and after this procedure in order to verify that the instrument's electrical characteristics have not been affected. Cover the unit with a plastic sheet when working on the cabinet. Clean the inside of the cabinet thoroughly when installation is complete. Replace the instrument in the cabinet as soon as possible after the work is completed.

To install the instrument in a rack:

a. Loosen the four captive 10-32 screws in the rear of the cabinet until the chassis is free; slide the chassis forward, out of the cabinet.

b. Match drill the cabinet for proper positioning of the rack-mount adaptors.

c. Remove the four feet and the bail from the cabinet if required for clearance.

d. Attach one Rack Adaptor Assembly (G) to each side of the cabinet using the hardware supplied.

e. Install the instrument in the cabinet and lock it in place with the four captive screws in the rear panel that were loosened in step a.

f. Slide the entire assembly into the relay rack and install it with the four 9/16-inch screws with captive nylon cup washers (E). Use two screws on each side and tighten them by inserting a screwdriver through the holes in the handles.

To reconvert the instrument for bench use, reverse the above procedure. Seal the mounting holes if the working environment warrants such action.

3.3 Connections

CAUTION

The voltage rating of the 1413 is 500 V pk maximum up to 10 kHz, varying approximately inversely with frequency above 10 kHz. Do not exceed these values.

3.3.1 Three-Terminal Capacitor

When the 1413 is used as a three-terminal capacitor, the outer conductors (shells) of the two bnc connectors must be connected together, to provide complete shielding.

If binding-post connections are desired, these can be provided by standard adaptors plugged into the bnc connectors on the rear of the 1413. Plug the adaptors into the 1413 with the shield binding posts adjacent to each other. These shield posts can then be connected together with a shorting link .

Section 4
Theory

4.1 Circuit Description

Each decade consists of four capacitors with values in the ratio of 1-2-2-5. They are connected in parallel in different combinations to provide ten equal steps of capacitance. Individual capacitors that are not used at a particular setting of the switches are completely disconnected from the circuit and their high side is connected to the inner or "guard" shield. The inner shield and the wiring are arranged to keep the capacitance at the zero setting to a very low value (< 0.1 pF) and to keep the capacitance from HIGH to case and from HIGH and LOW to the inner shield to a minimum.

An elementary schematic is shown in Figure 1-1 and the complete schematic circuit diagram is given in Figure 7-1.

4.2 Frequency Characteristics

Typical variations of capacitance and dissipation factor with frequency are shown in Section 2.

Section 5
Service

5.1 Customer Service

The IET warranty attests to the quality of materials and workmanship in our products. For application assistance or if difficulties occur, our engineers will assist in any way possible. If you cannot eliminate the difficulty, please e-mail, FAX, or phone our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to include the type and serial number of the instrument.

In the US call:

800-475-1220 or 617-969-0804 for technical support

800-899-8438 or 516-334-5959 for customer service

516-334-5988 for FAX

www.ietlabs.com

5.2 Instrument Return

Before returning an instrument to IET for service please call our Service Department at 800-899-8438 for a Return Material Authorization (RMA). Supply a Purchase Order Number or Credit Card information to insure expedient processing. Units under warranty will be repaired at no charge. For any questions on repair costs or shipping instructions, please contact our Service Department at the above number. To safeguard an instrument during shipment, please use packaging that is adequate to protect it from damage, (i.e., equivalent to the original packaging) and mark the box “Delicate Electronic Instrument” and also with the RMA number. Material should be sent freight prepaid to:

IET Labs, Inc.
10 Dedham Street
Newton Highlands, MA 02461

Attention: Service Department

Section 6
Maintenance

CAUTION

--The user should not attempt service or repair of any internal parts or assemblies. Return the instrument to IET of such work is required. See Section 5.2 for shipping instructions.
--Remove the cabinet only when converting the instrument from bench to rack mount or vice versa. See Section 3.2 for details.
--Store the instrument for short periods in a benign and dust-free environment (23 ± 10° C and <60% relative humidity); a laboratory environment is best. For long-term storage, seal the instrument in plastic--with desiccant if possible--and store at temperatures between 10° C and 50° C and humidity <80%; Calibrate before use. Since the 1413 is a precision instrument, IET recommends that any storage be in a laboratory environment.
--Clean the external surfaces of the instrument with a soft, dry cloth that may be moistened with a mild, general-purpose cleaner; compressed air may also be used. Keep the 1413 connectors and any mating connectors clean. Do not open the cabinet, and keep the rear cover plates in place, in order to keep the inside of the instrument dust-free.
--Replace the rear cover plates immediately after any adjustments are completed.

6.1 Minimum Performance Standards

6.1.1 General

The following tests can be used for incoming inspection, periodic checks, or recalibration of the 1413. The required equipment is listed in Table 6-1.

6.1.2 Capacitance

The equipment required to check the capacitance values of the 1413 is listed in Table 6-1.

Connect the UNKNOWN H and L terminals on the 1620 Capacitance Measuring Assembly to the HIGH and LOW terminals, respectively, on the 1413. Make the measurements at 1 kHz with the 3-terminal connection. Use appropriate patch cords up to 0.1 μF and twist them together for measurements above 0.01 μF to reduce the error due to inductance of the cables.

At 0.1 μF and higher, low-resistance connections are necessary to reduce the dissipation-factor errors caused by lead resistance. Install bnc-to-binding-post adaptors on the 1413. Place the instruments so that the binding posts on the adaptors are close to the bridge binding posts. Make the connections, with #12 AWG copper wire, from the bridge H and L terminals to the 1413 HIGH and LOW terminals. Connect a short clip lead from bridge GND to the shells of both bnc connectors on the 1413.

Maximum dissipation-factor readings are given in the Specifications.

6.1.3 Terminal Capacitance

Use the 1620 Capacitance Measuring Assembly to make the various terminal-capacitance measurements. The connections are given in Table 6-2.

6.1.4 Insulation Resistance

To measure the insulation resistance, use a GenRad Type 1863 Megohmmeter or equivalent. Measure the resistance between the inner conductors of the HIGH and LOW bnc connectors on the 1413. Connect the outer shells of both of these connectors to the GUARD terminal of the Megohmmeter; use alligator clip leads.

Apply 500 Vdc and wait two minutes before measuring the resistance.

Table 6-1
TEST EQUIPMENT

Number Required	Description	Recommended Type*
1	Capacitance Measuring Assembly (includes oscillator, amplifier and bridge)	GR 1620-A
2	Shielded patch cord/adaptor, GR874-to-BNC	
2	Adaptor, bnc-to-binding posts	
2	Special shielded cables, bnc connectors on one end, very small alligator clips on the other	
1	Single banana-plug patch cord, 18 inches or as short as possible	
4	Shielded clip leads with small alligator clips	

***Or equivalent**

Table 6-2
Connections for Terminal-Capacitance Measurements

Measurement	Connection	Lead Type
HIGH to Case	Bridge L to 1413 HIGH	Patch cord
	Bridge H to outer shell of 1413 LOW	Shielded clip lead
	Bridge GND to inner conductor of 1413 LOW	Single banana plug patch cord
HIGH to Guard	Bridge H to shell, and L to inner conductor of 1413 HIGH	Shielded clip leads
	Bridge GND to shell and inner conductor of 1413 LOW	Patch cord with alligator clips
LOW to Guard	Bridge L to 1413 LOW	Patch cord
	Bridge H to shell of 1413 HIGH	Shielded clip lead
	Bridge GND to inner conductor of 1413 HIGH	Single banana plug patch cord

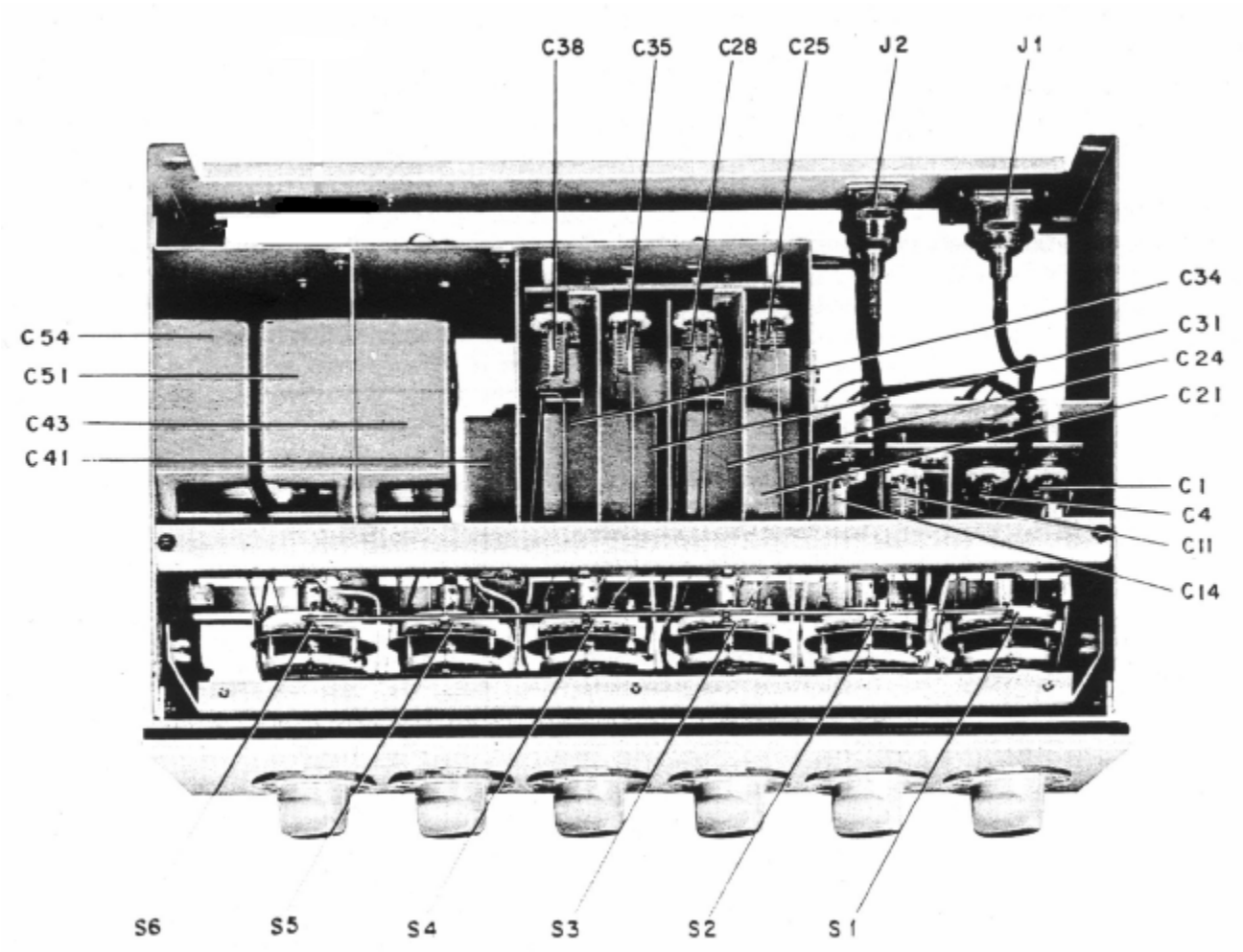


Figure 6-1. Top interior view of the Capacitor.

6.2 Adjustments

Most of the capacitance in the four highest decades of the 1413 Decade Capacitor is provided by high-quality, precision, sealed, mica capacitors. The capacitance in the two lowest decades (1 pF/step and 10 pF/step) is provided by small adjustable air capacitors (see Figure 6-1). Similar capacitors are provided for trimming the next two decades (100 pF/step and 1000 pF/step). These capacitors are carefully adjusted in IET's Calibration Laboratory and should not need readjustment for several years. When they are readjusted, a precision three-terminal bridge such as the 1620 Capacitance Measuring Assembly should be used. Set the bridge for three-terminal measurements and connect the capacitor to it with BNC-to-874 patch cords.

Remove the two cover plates over the adjustment holes (Figure 6-2) on the rear of the case. Do not remove the instrument from its case. Adjust the four trimmers in the decade (e.g.. those for the 10 pF/step decade, labelled 10, 20, 40, 50) in order, starting with the smallest. These numbers refer to the corresponding pF dial settings for that decade. Make the adjustments with a non-metallic screwdriver through the hole marked with the corresponding pF value. Set the switch for that decade to the pF value being adjusted, with all other switches set to zero. For example, to adjust the 10 pF/step decade, set that dial at 10. and adjust the trimmer marked 10 to give 10 pF from the HIGH to LOW terminals. Change the dial setting to 2 and adjust the trimmer marked 20 for 20 pF. Proceed similarly with 40 pF and 50 pF.

In the 1-pF/step decade, the capacitors are set to 1.01, 2.01, 4.01, and 5.01 pF, respectively. All other decades are set to the exact nominal value. When all values have been set. it is usually desirable to repeat the adjustment for a slight "touch-up."

6.3 Knob Removal and Replacement

If it should become necessary to remove a knob from the front panel to change one that has been damaged, proceed as follows:

a. Note the setting of the dial on the shaft, so that it can be replaced property; then loosen the collet nut in the hub of the dial and slide the dial off of the shaft.

b. To replace the knob, reverse the above procedure.

Section 7
PARTS LISTS AND DIAGRAMS

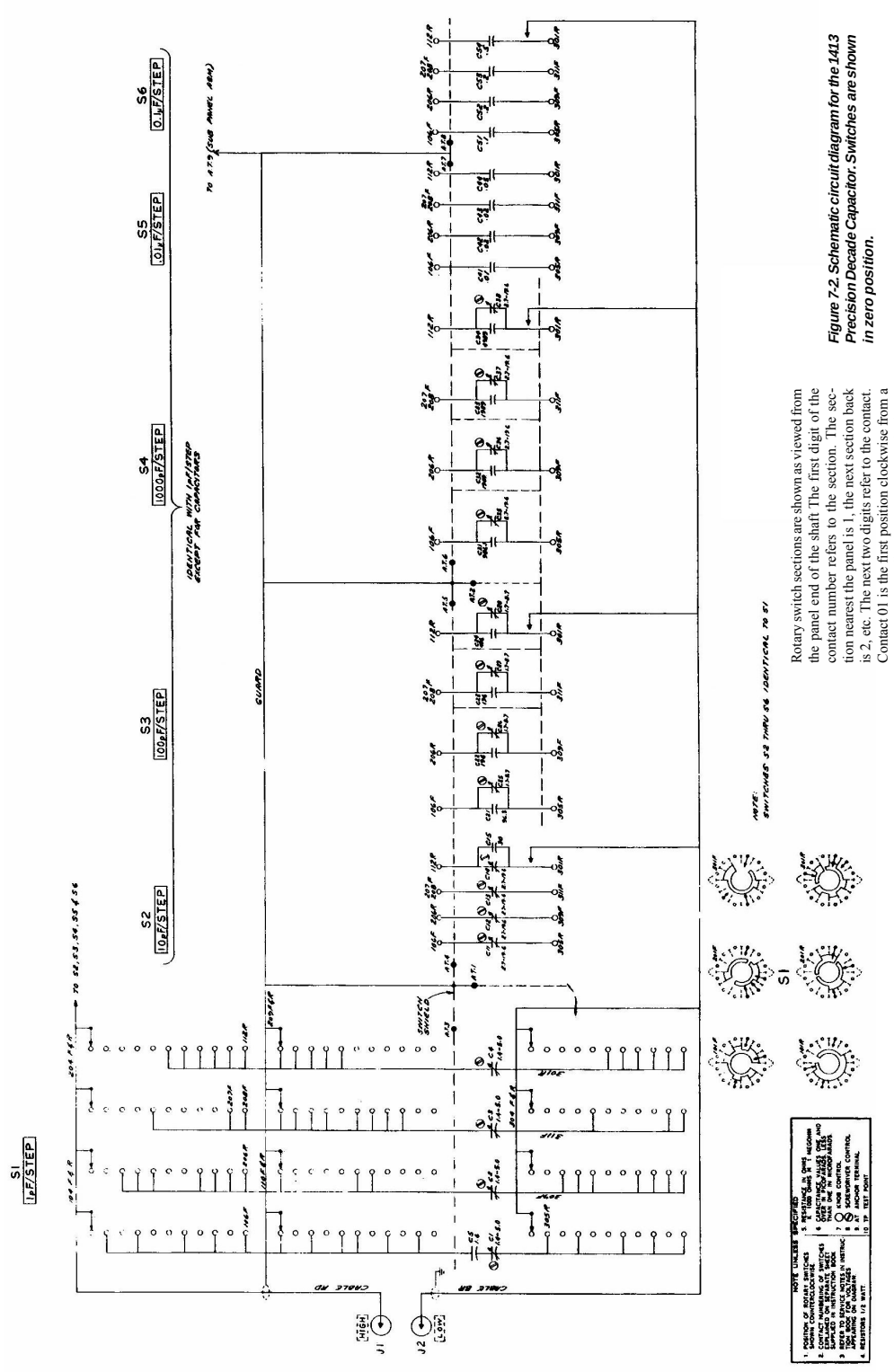


Figure 7-2. Schematic circuit diagram for the 1413 Precision Decade Capacitor. Switches are shown in zero position.

Rotary switch sections are shown as viewed from the panel end of the shaft The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc.), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

ELECTRICAL PARTS LIST

Ref Des	Description	IET Part No.
CAPACITORS		
Cl	Air Dielectric, 1.4-5.0 pF	4380-3500
C2	Air Dielectric, 1.4-5.0 pF	4380-3500
C3	Air Dielectric, 1.4-5.0 pF	4380-3500
C4	Air Dielectric, 1.7-8.7 pF	4380-3600
C5	Quartz, Var., 0.6-1.8 pF,	4910-1180
C11	Air Dielectric, 2.7-19.6 pF	4380-3700
C12	Air Dielectric, 2.7-19.6 pF	4380-3700
C13	Air Dielectric, 2.7-19.6 pF	4380-3700
C14	Air Dielectric, 2.7-19.6 pF	4380-3700
C15	Ceramic, 33 pF ±5%, NPO, 500V	4410-0335
C21	96.3 pF ±1 pF	0505-4030
C22	196.0 pF ±1 pF	0505-4031
C23	196.0 pF ±1 pF	0505-4031
C24	496.0 pF ±1.3 pF	0505-4032
C25	Air Dielectric, 1.7-8.7 pF	4380-3600
C26	Air Dielectric, 1.7-8.7 pF	4380-3600
C27	Air Dielectric, 1.7-8.7 pF	4380-3600
C28	Air Dielectric, 1.7-8.7 pF	4380-3600
C31	986.1 pF ±2.1 pF	0505-4033
C32	1989 pF ±5 pF	0505-4034
C33	1989 pF ±5 pF	0505-4034
C34	4989 pF ±5 pF	0505-4035
C35	Air Dielectric, 2.7-19.6 pF	4380-3700
C36	Air Dielectric, 2.7-19.6 pF	4380-3700
C37	Air Dielectric, 2.7-19.6 pF	4380-3700
C38	Air Dielectric, 2.7-19.6 pF	4380-3700
C41	10,000 pF ±2.5 pF	0505-4036
C42	20,000 pF ±5 pF	0505-4037
C43	20,000 pF ±5 pF	0505-4037
C44	.05 µF ±12.5 pF	0505-4038
C51	0.1 µF ±12.5 pF	0505-4039
C52	0.2 µF ±50 pF	0505-4040
C53	0.2 µF ±50 pF	0505-4040
C54	0.5 µF ±125 pF	0505-4041

MECHANICAL PARTS LIST

Front View (See Fig 1-2)

Qty	Ref	Description	IET Part No.
1	1	Cabinet asm., includes:	4181-2901
1		Bail*	
1		Gasket (mat'l.)	0051-0006
1		Foot, left front*	
1		Foot, right front*	
2		Foot, l & r, rear*	
		*Part of foot/bail kit	
6	2	Knob/Dial assembly	350020
6	3	Cap, knob	350019

Rear View (See Fig 1-3)

Qty	Ref	Description	IET Part No.
1	1	Connector, bnc, isolated (Std.) (Other types optional)	31-10/800-2540-03
1	2	Connector, bnc (Other types optional)	31-221/UG-1094
2	3	Cover Plate	1413-8190